

INDOOR AIR QUALITY ASSESSMENT

**Sunderland Elementary School
Old Amherst Road
Sunderland, Massachusetts**



Prepared by:
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Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Eric White, Sunderland Building Inspector, the Bureau of Environmental Health Assessment (BEHA) of the Massachusetts Department of Public Health (MDPH) provided assistance and consultation regarding possible mold growth at the Sunderland Elementary School (SES), Old Amherst Road, Sunderland, Massachusetts. The SES is a member of the Union #38 School District that services students in the rural portion of western Massachusetts. This request was prompted by concerns that gypsum wallboard (GW) that formed the attic area was mold contaminated. Concerns stem from moistening of building components caused by chronic roof leaks and subsequent collapse of a portion of the roof during the winter of 2003.

On October 31, 2003, a visit to the SES to conduct an indoor air quality assessment was made by Michael Feeney, Director of the Emergency Response/Indoor Air Quality (ER/IAQ) program, BEHA. Mr. Feeney was accompanied by Steven Caulfield, Turner Building Science, LLC, Mr. White and other individuals. At the time of the assessment, the building was under construction/renovation.

The SES is a one story, multi-wing structure built in 1988. The school was designed to house elementary school students from grades K through 6. In February 2003, the middle portion of the roof buckled from the weight of heavy snow. Following the roof collapse, the school was closed and renovation activities commenced. Major alterations were made to improve the building envelope and remediate roof structure problems. Some of these activities include:

- Restructuring of the roof (Picture 1);
- Removal of GW in a majority of areas in the building;

- Installation of a new ventilation system;
- Reconstruction of the exterior walls (Picture 2); and
- Installation of a vapor barrier to the slab.

At the time of this assessment, work on the main classroom wing and cafeteria/kitchen areas appeared to have been completed. The kindergarten classrooms and art room section of the building were actively under renovation during this assessment (Picture 3).

Methods

Visual observation of GW for mold was conducted. Water content of GW was measured with a Delmhorst, BD-2000 Model, Moisture Detector that is equipped with a Delmhorst Standard Probe. Air tests for temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, 8551 Model.

Results/Discussion

The building was evaluated on a relatively warm day, with an outdoor temperature of 63°F and relative humidity of 48 percent. Indoor relative humidity was measured in a range of 38 to 46 percent, lower than outdoor measurements. The last recorded rainfall in the SES area occurred October 29, 2003 (Weather Underground, 2003), two days prior to this assessment. During the assessment, no active leaks were observed. Furthermore, no visible, accumulated moisture was noted on ceilings, walls or the cement floor.

Moisture measurements of GW were taken in areas with a documented history of water damage. In many areas, GW did not have measurable moisture levels. However, a GW window frame in the library (Picture 4) and some GW walls in the art room and

kindergarten classrooms had moisture concentrations ranging from 0.6 percent to saturated. With the exception of the window frame, these moisture concentrations were found in interior walls. Walls were adjacent to kindergarten restrooms, which had ceramic tile walls or walls consisting of wooden cabinets. Since ceramic tiles are non-porous and wood has a higher saturation point than GW, these materials do not readily absorb moisture. Instead, the materials held moisture against GW walls. As a result, GW walls leading to the art and kindergarten rooms became moist and were colonized with mold. Bare GW in one kindergarten classroom had visible mold colonization (Picture 5). Exploratory holes made in kindergarten room wall cavities revealed mold colonization on GW at the floor level (Picture 6). This mold growth indicates that GW was saturated with water.

As part of the assessment, BEHA staff examined the attic crawlspace above the finished classrooms. Concerns of mold colonizing wood and GW in the crawlspace were raised. According to Sunderland town officials, the crawlspace is subjected to repeated water damage caused by roof leaks in the areas surrounding the exhaust system vents. Sunderland town officials also reported that the roof of the building is prone to developing ice dams, providing another means for water to penetrate into the attic space.

Ice dams occur when snow in contact with the upper section of the roof melts and refreezes on the lower portion of a roof. Heated air from occupied spaces rises and gathers in the peak of the roof. Heated air at the peak then warms roofing materials. Once roof materials are warmed above water's melting point (32° F), snow in contact with these materials melts. As water rolls down the sloped roof, it freezes on the lower section of the roof when it comes into contact with materials that are below 32° F, creating an ice dam.

The dam collects and holds melting snow or rainwater against the roof shingles. Pooling water can then penetrate through the roof materials via cracks and crevices, thus wetting the interior of the building. A combination of standard building practices is used to prevent ice dams. These practices include the following:

- Insulating the floor of the attic space to prevent air movement and heat loss from the occupied space.
- Installing ridge vents along the roof ridge to allow heat to exhaust from the attic space.
- Installing soffit vents beneath the eave in the roof to provide a means for cold outdoor air to enter and replace heated air that escapes through the ridge vent.

This configuration allows heat to escape and also tempers air in the attic space to temperatures approximately equal to outdoor temperatures. In this manner, melting of snow in contact with roof materials and subsequent ice dam formation can be prevented. If attic insulation were inadequate or ridge vents/soffit vents were sealed, heat could accumulate in the roof peak and the ice dam creation cycle could commence.

It is likely that the SES attic space configuration that made the roof prone to developing ice dams also helped dry attic materials, thereby preventing mold colonization. As described by town officials, the building had neither a peaked roof with a ridge vent nor insulation in the attic floor. Under these conditions, heated air from the classrooms would readily rise through the ceiling system and accumulate in the roof peaks. While the rising heat created conditions that generated ice dams, the heat also helped to dry moistened building materials. Operation of the heating system allows heated air to

accumulate in the ceiling, subsequently aiding in the drying of building components (e.g., roof rafters, trusses, and other wood and GW components). The key to preventing mold growth in building components is drying moistened materials as soon as possible.

In order to become colonized with mold, a material must be exposed to water and remain moist. If sufficiently moistened, porous materials such as cardboard, GW and carpet can all support mold growth (US EPA, 2001). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a fungicide to moldy carpeting is not recommended.

The absence of visible mold colonies and lack of musty odors in the attic space suggests that the drying effects produced by heated air in the attic prevented mold colonization of building components. Recent roof reconstruction activities were integral in removing water-damaged materials from the attic. During the roof reconstruction, elements to prevent ice dams (e.g., installation of ridge vents) were also incorporated.

Other potential sources of mold were also examined. During the course of the assessment, boxes of books in the library were examined. As reported by school officials, these book boxes were stored in a container outside the school during the renovation. No visible mold colonization or musty odors were emanating from the boxes. Several books within boxes were spot-checked and were found to be free of visible mold colonization and/or musty odors. With the absence of visible colonies or musty odors, it is unlikely that the books sustained mold damage while in storage. Please note that BEHA staff did

not check every box stored in the library. If materials are found water damaged, as is the book in Picture 7, discarding them is advisable. Sunderland School Department officials reportedly advised teachers to discard water-damaged materials.

Other materials were found to be mold colonized. A couch with a concealed mattress that is stored in the cafeteria had a distinct musty odor (Picture 8). Upholstered furniture in schools can become a source of environmental pollutants. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. Moreover, dust mites tend to proliferate when relative humidity levels are above 60 percent (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that upholstered furniture present in schools be professionally cleaned on an annual basis. If outdoor conditions or indoor activities (e.g., renovations) create an excessively dusty environment, cleaning frequency should be increased (e.g., every six months) (IICR, 2000). Elevated outdoor levels of airborne particulates can result in increased levels of indoor particulates since pollutants can enter into the building through open windows, doors and filter bypass.

Lastly, the large planter (Picture 9) located in the cafeteria can also be a point for mold proliferation. Plant soil and drip pans can serve as a source of mold growth. Plants should be properly maintained and be equipped with drip pans. To prevent aerosolization of dirt, pollen or mold, plants should be located away from the air stream of mechanical ventilation.

Conclusions/Recommendations

The Union #38 School District has clearly taken a number of positive steps to remediate the roof collapse and other water penetration problems at the SES. The majority of these actions have served to improve the conditions in the building. Measures to repair the roof, install vapor barrier on the slab and a new ventilation system and remove GW will all help to decrease adverse conditions impacting indoor air quality. Some conditions remaining in the art and kindergartens classrooms (e.g., GW walls) and the library (e.g., window frame) warrant further attention. In view of the findings at the time of this assessment, the following recommendations were made:

1. Replace all GW that have visible microbial growth.
2. Examine the GW behind cabinets in the art room and kindergarten classrooms. If mold colonized, remove and replace GW at least one foot above the floor level.
3. Examine the GW behind tiled walls of the kindergarten restrooms. If mold colonized, remove and replace GW at least one foot above the floor level.
4. Remove water saturated GW from the library window (Picture 4).
5. Discard couch in cafeteria.
6. Clean upholstered furniture in the building according to the schedule recommended above. If not possible/practical, remove upholstered furniture from classrooms.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Berry, M.A. 1994. *Protecting the Built Environment: Cleaning for Health*, Michael A. Berry, Chapel Hill, NC.

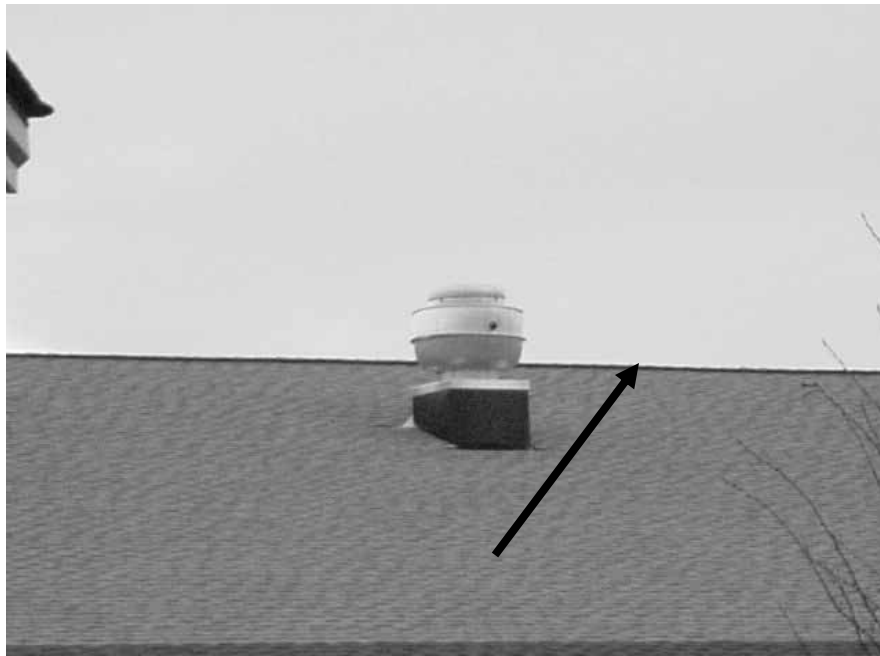
IICR. 2000. IICR S001 Reference Guideline for Professional On-Location Cleaning of Textile Floor Covering Materials Institute of Inspection, Cleaning and Restoration Certification. Institute of Inspection Cleaning and Restoration, Vancouver, WA.

The Weather Underground. 2003. Weather History for Orange, Massachusetts, October 29, 2003 through October 31, 2003.
<http://www.wunderground.com/history/airport/KORE/2003/10/31/DailyHistory.html>
<http://www.wunderground.com/history/airport/KORE/2003/10/30/DailyHistory.html>
<http://www.wunderground.com/history/airport/KORE/2003/10/29/DailyHistory.html>

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

Picture 1



Restructuring Of the Roof (Note Ridge Vent)

Picture 2



An Example of Reconstructed Exterior Walls

Picture 3



Building Wing Consisting of Kindergarten and Art Room

Picture 4



Water Saturated Section of Library Window Frame

Picture 5



GW in Kindergarten Classroom with Mold Colonization

Picture 6



Kindergarten Wall Cavity Mold Colonization in GW at Floor Level

Picture 7



Water Damaged Book

Picture 8



Moldy Couch in Cafeteria

Picture 9



Planter in Cafeteria